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Wood Waste In Ohio

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WOOD WASTE IN OHIO

J. W. METEER

SECTION I

As forestry practices have intensified in the United States, there has come the realization that the utilization of inferior materials is the key, not only to intensified woods practices, but also to the overall economy of the wood-using industries. An analysis of wood utilization shows that on a nation-wide average, 57 percent of the annual timber harvest is classified as wood waste (12). (Although a considerable amount of this material finds some use as fuel.)

Research in wood utilization has been directed toward the perfection of products and processes in which wood waste can be used as a raw material. A number of manufactured products have been developed and are on the market. Others are being produced in test laboratories and pilot plants. The next step in the solution of the wood waste problem is to delve into the supply of raw material, its acquisition, transportation, and cost.

This study was organized after general inquiries had indicated a growing need for information and after two organizations indicated they planned to bring new industries into Ohio if they could be reasonably certain of a supply of wood waste.

Surveys of the wood-using industries were made in an attempt to determine how much wood waste is produced, what is done with it, under what conditions it would be available for new markets and any other information related to use, value, and experiences in handling and transporting material.

The study was carried on in two phases. Phase one consisted of an intensive survey of sawmills and secondary plants in northeastern Ohio and is recorded in Section II. Section III covers the study over the remainder of the state. This latter was an extensive survey of only the larger secondary plants.

Wood Waste is considered to be the residues or offal from the production of lumber and the manufacture of wood products (pulp excluded). This is classified as: (1) waste from primary manufacture—the manufacture of lumber, veneer, staves, etc., from logs: (2) waste from secondary manufacture—the manufacture of furniture, millwork, barrels, etc., from lumber or rough cut stock; and (3) logging waste—material left in the woods on the logging operation, such as branches;

split, defective, and otherwise low-grade logs, high stumps, etc. Logging waste is not included in the tabulations of this survey because of its relative inaccessibility and the problems of collection and transportation.

The Nature of Wood Waste

Although this report is concerned with the waste produced and does not go into the factors causing waste, a few comments may be in order.

The significant cause of waste is, of course, the fact that wood-working processes produce an offal. However, this wood residue is greatly increased by the presence of large quantities of mismanufactured, improperly cared for or poorly graded lumber often produced by small sawmills. Another cause is the failure to use (or inability to obtain) the particular grades and sizes of lumber that will most efficiently produce a given material. A third cause is the failure of many factories to utilize fully the material available. For example, furniture factories often produce waste up to 25 or 30 percent of their lumber consumption Some plants have glue rooms where great quantities of cuttings are used in edge-glued stock and glued-up blocks, reducing waste to as low as 5 percent. A parallel situation exists in sawmills where many operators slab to an 8 or 10-inch face while others start cutting lumber at four inches. Much slabwood is burned or discarded while a few mills run slabs back through resaws to produce thin crating or small dimension for hardwood plow beams and other articles.

It can be seen that the solution of the wood waste problem is not wholly a matter of making fabulous new products from sawdust and shavings. Much beneficial action can come from within the wood-using industry of today; perhaps from within the very plants where waste is such a severe problem.

Primary Wood-Using Industries. Sawdust, slabs, trimmings, edgings, and occasionally, shavings from sawmills are the important waste products from primary wood-using industries. At small portable mills the waste is piled as it is produced, to be burned, left in the woods, or occasionally hauled away for minor uses or (in the case of slabwood) worked into other products such as firewood. In larger mills, slabs are worked up as they come down the rolls and, although occasionally going to resaws for remanufacture, usually go into a pile for firewood. Sawdust is piled out-of-doors and is exposed to the weather, only occasionally going into bins for use as fuel or for loading onto trucks. Sawmill waste is from green material and may contain 80 to 90 percent moisture (percent of oven-dry weight). (2). However, after a few months, slabwood will dry out to a 30 to 40 percent moisture content. Primary in-

dustries other than sawmills are basket veneer plants, whose waste is veneer trim and core, and stave mills, whose waste is sawdust, stave trimmings, and rejects.

Fig. 1.—The sawdust and slabs above are typical of waste from Ohio's portable sawmills. The sawdust is left in the woods. In this case the slabwood is burned as it is produced.

Secondary Wood-Using Industries. The offal from secondary wood-using plants is normally in the form of sawdust, shavings, and small cuttings. Many mills have blower systems to collect sawdust and shavings, which are stored in bins until burned or hauled away. Cuttings are usually thrown into scrap boxes to facilitate handling and then burned, sold, given away, reworked or hogged (ground). Only in occasional plants are cuttings handled mechanically on a chain conveyor system. Waste from secondary mills is air or kiln dried, with moisture content ranging from 7 to 15 or 20 percent.

SECTION II

WOOD WASTE IN 23 NORTHEASTERN OHIO COUNTIES

In 23 northeastern Ohio counties, the survey tabulated the wood waste from those secondary manufacturing plants that produced 5 tons of wood waste or more per week and those sawmills that produced 10 tons or more. Smaller plants, such as planing mills operated in conjunction with retail lumber yards, are quite numerous and, while they may contribute substantially to the wood waste picture, they present problems of collection and transportation that would be a serious hindrance to large scale industrial use.

Fig. 2.—The cyclone above is typical of those used to carry sawdust and shavings in many secondary plants. This building was built especially to handle wood waste from the main plant.

The Amount of Wood Waste

The waste production in the 23 counties covered by this study was 4,735 tons per week (of which almost 70 percent is produced by sawmills) from some 220 plants—an average of 22½ tons per week from each plant. In addition, there are at least 75 small woodworking shops and 175 to 200 small and part-time sawmills from which waste production was deemed too small to tabulate; so the above figure does

not represent total waste. No actual count was made of waste materials on hand since data were collected on current production only. (See appendix A for a detailed analysis by counties of the data presented in Figures 3, 4, and 5).

The Classes of Wood Waste

Figure 3 shows the breakdown of waste production by class of material as well as the availability and present disposal of these materials. Sawdust and shavings from secondary mills were classified together because it is quite common for these (and sanderdust, where present) to be mixed together in the plant collection system, and in only a few instances are separate figures available. Such mixtures are usually comprised largely of shavings. Where cuttings are hogged and all material mixed together for fuel, it was particularly difficult to classify the material. The classification of slabwood includes trims and edgings, both relatively unimportant. For convenience of presentation the small amount of veneer trim and core from basket mills was also included in the slabwood classification. The relative importance of slabwood in the wood waste picture is evident in Figure 3.

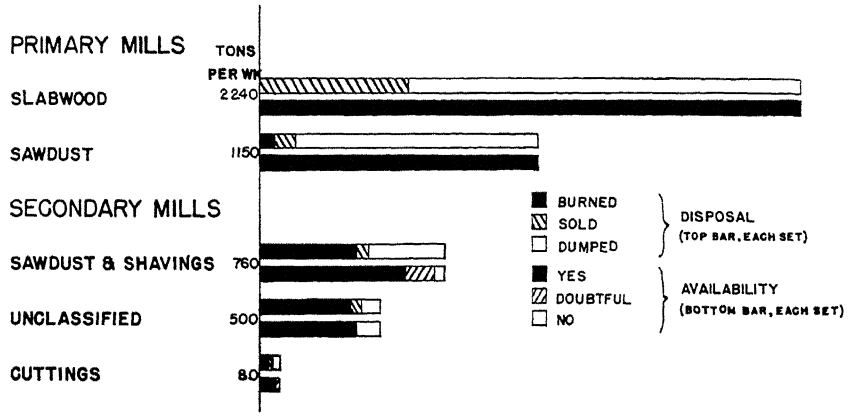

Fig. 3.—Weekly production of wood waste in northeastern Ohio. Disposal and availability are indicated by the top and bottom bars, respectively, in each set.

The Disposal of Wood Waste

The graphic portrayal of the disposal of wood waste in Figures 3 and 4 indicates that a relatively small amount is sold for other uses, about 16 percent, a little more is burned for fuel at the point of origin,

18 percent, and the remainder, 66 percent, is left piled in the woods, burned in incinerators, hauled and dumped, or given to anyone that will haul it away. This remainder, 66 percent of the material, gives an idea of the problem wood waste presents to the wood-using industry. Even so small sawmills located in the woods, the use or disposal of sawdust and slabs is a problem, while to the secondary manufacturing industries, almost all located in densely populated areas, the problem becomes critical. Approximately one-third of the material surveyed in the secondary plants in northeastern Ohio had no use or sale value, and in almost every factory visited the management explained that their first consideration in wood waste was to get rid of it in the manner that involved the least cost to them.

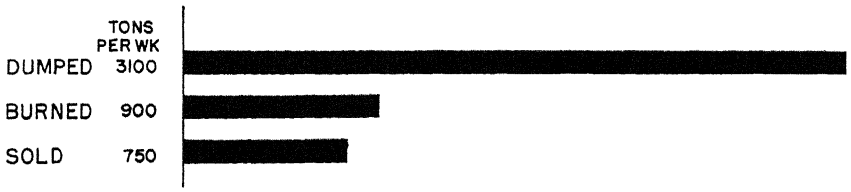

Fig. 4.—The disposal of the average weekly waste production in northeastern Ohio. (Total of both primary and secondary industries.)

The Distribution of Wood Waste

Of particular importance in developing an acquisition program for wood waste is the type of factories producing such material and the amount produced by the various factories. Figure 5 is an analysis of the types and numbers of plants, segregated according to the amount of waste material produced weekly. The effect of the large number of sawmills on the overall waste picture is readily evident. It is also seen that the majority of the waste from the secondary plants in northeastern Ohio is produced by a few large factories.

Concentrations of secondary wood-using plants are in Cleveland and Akron, with a few in Wooster, Norwalk, the Youngstown-Warren area, and in Columbiana, Stark and Ashtabula Counties. Sawmills are scattered through the area, being most numerous in the eastern-most counties.

There are several sawmill operators who operate from three to nine portable sawmills over a good portion of the state. A large supply of waste would be available through contacts with these operators.

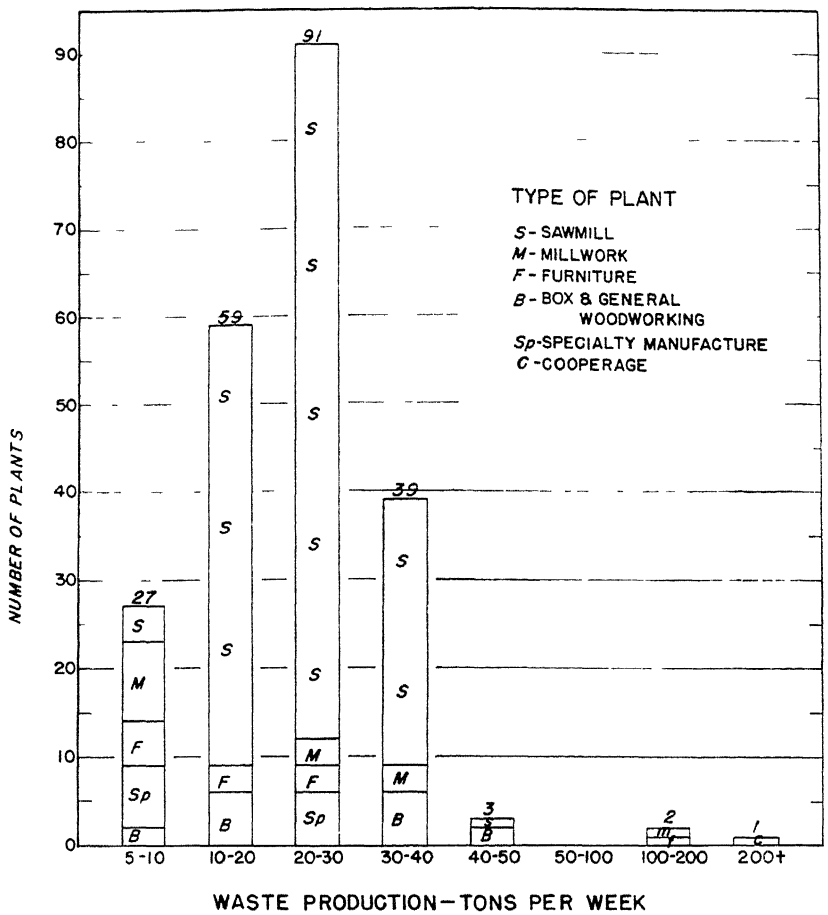

Fig. 5.—The number and types of plants in northeastern Ohio segregated according to the amount of waste produced weekly.

The various types of plants with general notes on the species and class of material at the various mills are listed as follows:

Type of Plant	Class of Material	Species
Sawmills (including a few other primary mills such as basket veneer)	2/3 slabwood, trims, and edgings; 1/3 sawdust	All hardwood species, mostly oak and maple.
Millwork	Mostly shavings, sometimes considerable cuttings, some sawdust	Softwoods, mostly white and sugar pine; some redwood and occasionally maple, birch, and beech.
Furniture	Mostly shavings and cuttings, some sawdust (quite variable)	All species, mostly hardwoods—maple, birch, and beech.
Specialty & Turning	Mostly shavings and cuttings, some sawdust	Usually hardwoods, maple, and others.

Type of Plant	Class of Material	Species
Box & General Woodworking	Mostly sawdust, cuttings variable, few shavings	All species—mostly hard wood, gum, some oak, and others; some pine
Flooring	Mostly shavings and cuttings	Hardwood—oak.
Tight Cooperage	Large quantities of cuttings and shavings	White oak

The Availability of Wood Waste

Figure 4 indicates that much of the wood waste produced in the area goes unused.

Even more important than the total amount of waste produced is the question of its availability for new uses. As seen in Figure 3, all but a very small percentage is available for new markets. Where there is a present use or value for the material, the prospective purchaser must meet this value. The only other requirement is that the plant management be assured that the material will be disposed of at regular intervals.

Slabwood is quite readily available while material from the secondary plants would be more difficult to obtain.

Use and Value of Wood Waste

Waste material from wood manufacture has a number of widely varied uses; however, most goes to small local markets or for fuel at the manufacturing plant. In many cases the value received is little more than the cost of handling the material. In these cases, the important consideration is not the value but the necessity of disposing of the material.

The Forest Products Laboratory (7) lists many uses for wood waste, including smoking meat, cleaning fur, polishing metal, insulation, floor sweeping compound, fuel briquettes, mulch, bedding, making porous fire brick, and for conversion into plastics, pulp, chemicals, wall board, wood molasses, composition flooring and many other uses.

Unfortunately, most of these uses are, at present, too limited to be of significant economic importance as outlets for wood waste. Only two or three larger plants have been able to take advantage of the sawdust markets by screening their sawdust to size and sometimes separating it by species to meet required specifications.

Two large producers are converting sawdust and shavings to wood flour and shipping carload lots to go into plastics and dynamite.

Other plants have only limited outlets to small local markets, some of which are as follows:

1. Job truckers buy sawdust to haul to brick plants.
2. Farmers occasionally use sawdust and shavings for mulch and bedding.
3. In large cities sawdust dealers provide a limited outlet.
4. Sawdust and shavings are sometimes sold as floor cleaning material to machine shops and meat markets.
5. Slabs are made into mine caps in the coal mining regions.
6. Slabs and veneer core are sold for firewood in some counties.
7. Slabs are occasionally worked into small dimension and thin box shook.

Fig. 6a.—(Top). This slab pile is located at least 50 feet from the sawmill, making it necessary for the offbearer to carry slabs that distance. Before the slabs are neatly ricked (as at center rear), they are picked up, buzzed, and then thrown into another pile (as at center). These slabs have accumulated during the summer months (up to August 1) at a typical semi-portable mill.

Fig. 6b.—(Bottom). Efficient handling of slabs at a small sawmill in Stark County. Firewood is handled by conveyor at a minimum of handling costs and is accumulating for sale during the winter months.

In Figure 7, the present uses or disposal of waste are tabulated on the left with the average value realized. The bars represent the number of plants that fit each classification.

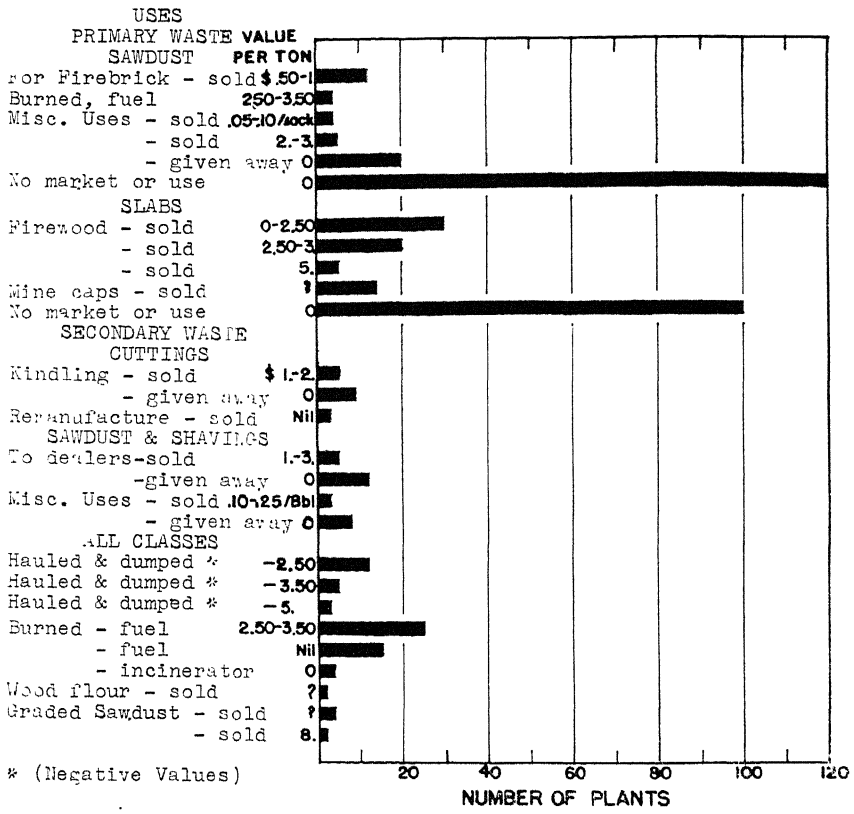

Fig. 7.—Wood waste and value chart for northeastern Ohio. The uses of wood waste in northeastern Ohio are outlined in the printed column on the left. In the center column are the values reported for each use. The bars on the right indicate the number of factories or sawmills which reported the various value classifications.

Wood, with a B.T.U. capacity of about one-half that of coal, is usually estimated (for fuel at the plant of origin) to be about half the value of a ton of coal. This value will range from $2 to $4 or occasionally more in northeastern Ohio, depending on the cost of coal at the different factories. When the inefficient nature of the wood-burning fuel systems is considered, these figures could be reduced by one-third in most cases.

Screened sawdust for making porous firebrick brings about $6 per ton delivered, but few mill operators realize over 50c to $1 per load from the job truckers.

No information was obtained on the value of wood flour or graded sawdust, except that one operator reported $8 per ton for sawdust loaded on cars. There is reason to believe, however, that wood flour is worth $20 to $25 per ton.

The presence of native coal and natural gas in several northeastern Ohio counties has rendered slabwood practically valueless. In other counties slabwood sometimes is worth $2 to $3 per short cord (delivered), although subject to much variation.

Firewood and sawdust dealers obtain some material from secondary mills but the value is low, and it is a common practice to give material to such dealers in order to get it out of the way.

Of great importance in the consideration of values of wood waste is the subject of handling, loading, and transportation. Where cyclone refuse collection systems are in operation, sawdust, shavings, and hogged material can be blown into bins prior to loading or can be blown directly into box cars for railroad transportation.

Truckers hauling sawdust from sawmills sometimes screen the sawdust, load by hand, and haul 30 to 50 miles and apparently make enough profit to stay in business.

A few observations on transportation and handling of wood waste are listed. These observations were originally made in northeastern Ohio but were found to apply over the remainder of the state.

Railroad Transportation

1. Most of the larger secondary mills have railroad sidings, as do some of the smaller ones, while hardly any of the sawmills are located on sidings.
2. A blower system is essential in handling and loading fine material.
3. To escape demurrage charges, a small mill wishing to ship by rail should have a bin capable of storing wood waste in carload lots.
4. A 50-foot box car can haul 20 to 30 tons of dry sawdust or wood flour. The minimum weight per car allowed by the railroads is 15 tons of sawdust and/or shavings.

Truck Transportation

1. Most manufacturing plants are not interested in trucking their waste.
2. A large semi-trailer will haul 12 to 15 tons of sawdust.
3. Efficient loading seems possible with portable blowers.

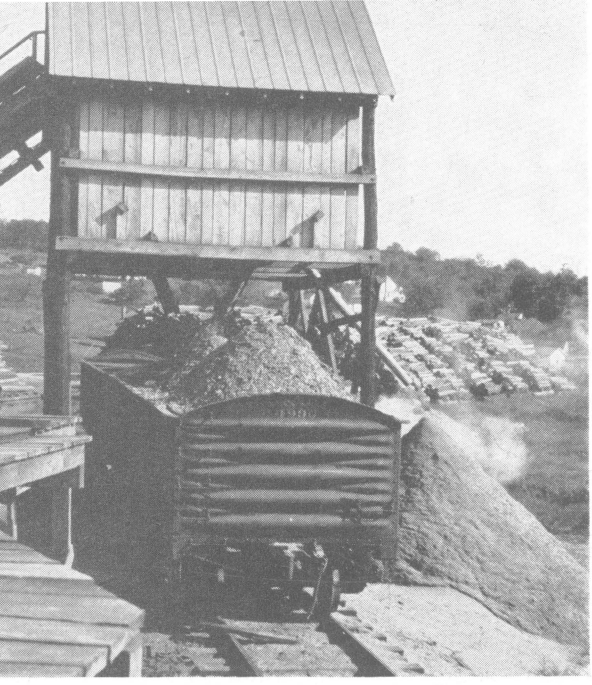

Fig. 8.—Wood chips being loaded on cars for transportation by rail. Cuttings are carried up the conveyor (upper left) to the hog. This simple installation works well.

General

1. Many plants now burning waste for fuel would have to change their cyclone and storage systems in order to market their waste.

2. Milling-in-transit freight rates offer an opportunity to ship wood waste, under prescribed conditions, at a reasonable cost.

3. Slabwood sold as firewood hardly pays for the cost of loading and hauling, except in cases where handled mechanically.

4. Cuttings are difficult to handle, especially in the absence of waste conveyor systems and had best be hogged for efficient handling.

5. It does not seem advisable to fix any average costs of transportation and loading because they are so variable. In some cases, waste has been shipped on milling-in-transit rates at a negligible cost. The information has been volunteered by several factories that waste could be transported for 75 to 100 miles for $2.50 to $3.50 per ton. One railroad quoted freight rates of $3.80 for sawdust and shavings and $3.60 for wood flour for a 90 mile haul and $7.40 for sawdust and shavings and $6.60 for wood flour for a haul of slightly over 200 miles. However, since wood flour and graded sawdust are being shipped considerable distances (up to approximately 500 miles in the case of wood flour produced from one mill), it indicates either that in some cases it is economically feasible to ship under existing freight rates or that special rates have been worked out.

The Ratio of Waste to Production

Because fluctuations in business cycles usually affect the wood-using industries rather strongly, it was felt that it would be desirable to tie in waste production with the wood consumption or production of the various factories.

Operations are quite variable from plant to plant because of differences in utilization practices, plant efficiency, and type of product. Coupled with this is the fact that few plants have an accurate estimate of their waste; so any standardization of a waste-production ratio must be very general.

On the average, sawmills produce one-third ton (one cubic yard) of sawdust and two-thirds to one ton (one to one and a half short cords) [1] of slabs and edgings per thousand feet of lumber sawed.

In general, estimates from the various woodworking plants indicate that millwork plants produce 20 to 25 percent waste; furniture plants, 25 to 30 percent; turning and specialty mills often produce 35 to 40 percent; planing mills, 20 percent; box plants, 20 percent and cooperage plants, over 50 percent waste.

A confusing issue is the fact that several manufacturers who have made waste studies for cost analysis purposes usually figure total board foot intake and total output of material translated in terms of board footage. The difference, their board footage loss, is called waste. No account is made of any turning, moulding, or planing operation that does not reduce board foot content.

Thus, many firms produce sizeable quantities of shavings over and above their estimate of waste.

Other factories keep track of their waste by the number of loads of sawdust and shavings hauled away. When cuttings are burned, given to employees, kindling dealers, and local residents, they often do not figure in the overall waste estimate.

These two factors, plus a complete lack of information at many factories, made it difficult to obtain reliable estimates and have led to estimates that are undoubtedly quite conservative in many cases.

After an estimate of waste production was obtained, this estimate was usually checked with the plant management by questioning them on their percent of waste and their total lumber consumption. By converting board feet to tons per week and applying the percent of waste, it was possible to check on the original estimate. This system helped considerably, assuring that the estimate fell within reasonable limits and served to arouse interest and invoke deeper thinking on the part of the plant management.

[1] A short cord is a "rick" 4 feet high by 8 feet long of 16 or 18 inch firewood.

SECTION III

WOOD WASTE IN 65 OHIO COUNTIES[1]

In an extensive study of wood waste covering the remaining 65 counties in the state, data were tabulated only from those secondary plants producing 25 tons or more per week.

Since shavings are more suitable than sawdust for uses in fibre products and since the handling of cuttings imposes problems quite different from handling hogged material, a special effort was made to obtain separate figures for each of these classes. The classes of material considered were then: (1) sawdust, (2) shavings, (3) sawdust and shavings, (4) cuttings, (5) cuttings-hogged, and (6) unclassified where separate estimates were unavailable on the amount of material in the different classes.

It was an inquiry from a large pulp and paper company that brought about this part of the study and new advancements in pulping have broadened the field to the point where wood waste (including most of the hardwood species) can seriously be considered as a raw material.

Information was collected on the waste production by classes as indicated above as well as data on species, value, transportation and handling, and uses and markets. As in the previous study, material was classified as to its present use (burned for fuel, sold, and dumped or given away) and its probable availability for new markets.

Analysis of Waste Production

Waste production from secondary wood-using factories in the 65 counties totals 2,200 tons per week from those plants producing 25 tons or more. Appendix B gives this information in detail, showing the location of waste by counties and the breakdown into various classes.

The total number of plants is 40 (of these, no estimates were obtained from five mills), making an average of 63 tons per week per plant.

The greatest concentration of large wood-using industries is in the southwestern portion of the state, which produces approximately 980 tons of waste per week. Sums of 530 and 670 tons per week, respectively, were found in southeastern and northwestern Ohio. Figure 9 illustrates the total breakdown by classes as well as the disposal and availability. Lack of sufficient information accounts for the large amounts of waste in the "unclassified" columns. Hogged material is in greater evidence than this figure would indicate.

[1]Other than the 23 counties in northeastern Ohio covered in Section II.

The hogged waste is ordinarily found at plants which burn their waste for fuel. Many of these mills, having no means of segregating or measuring the components of the cyclone output, could provide no estimate on the various classes of material. Also, it was quite often difficult to obtain separate figures for shavings because they are commonly mixed with sawdust and hogged material.

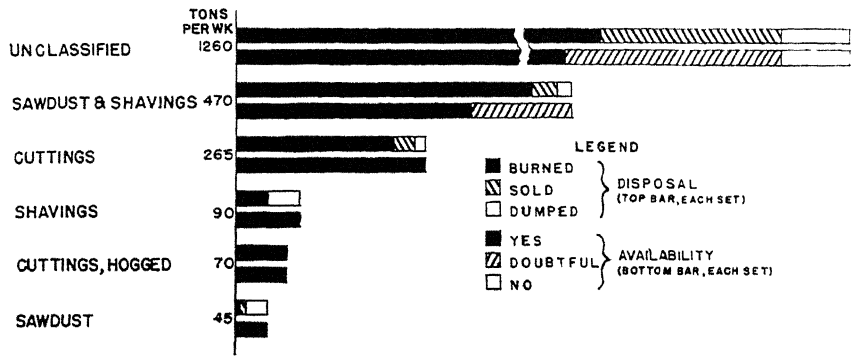

Fig. 9.—Weekly production of wood waste from 35 of the largest plants in northwestern, southwestern, and southeastern Ohio.

The Disposal of Wood Waste

The disposal of waste material is classed as sold, burned (for fuel), or dumped (including given away, burned in incinerators, and hauled and dumped). In Figure 9 the top bar of each pair indicates the disposition of each class of material while Figure 10 shows the overall relationship.

Fig. 10.—The disposal of the average weekly production of 35 large secondary mills in northwestern, southwestern, and southeastern Ohio.

Three-fourths of the waste tabulated on this portion of the study is burned for fuel at the plant of origin; quite a different situation than was found in the northeastern Ohio survey which took data from the many small factories and the primary wood-using industries. The larger mills produce great quantities of waste and on occasions when waste

disposal systems have broken down, the accumulation of material has forced plant shutdowns. In the face of such a waste problem, most mills, in the absence of steady markets, have developed highly efficient fuel systems which solve their disposal problems and yield them a fair value return, thus accounting for the high percentage of material that is used for fuel.

Material sold goes to high-value specialty markets that have a steady demand. Wood flour, graded "sawdust" or fine chips, and some hogged material are sold for various uses.

The Availability of Wood Waste

The lower bar of each pair in Figure 9 shows, for each class of material, the probable availability for new markets. As indicated in Figure 11, about 75 percent of the material is classed as "probably available", with 22 percent of "doubtful availability", and 3 percent "definitely not available".

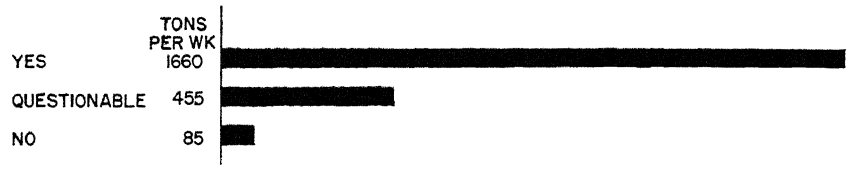

Fig. 11.—Tentative availability (subject to price offered)of weekly waste production from 35 large secondary mills in northwestern, southwestern, and southeastern Ohio.

Availability as recorded here was determined by the owner's expressed willingness to sell or talk business on suitable arrangements for sale. However, one very important factor was noted that has proved difficult to tie down or evaluate. Although the plant management in many instances indicated a willingness to sell their wood waste, the provision was added that "of course, the selling price must compensate us for the present value derived from the material and we must be assured it will be regularly taken off our hands". It can be seen that the classification "available", as used in this report, includes material that is available only if the price is right. In general, this is quite a different situation than was found in northeastern Ohio where the small plants and sawmills were included in the survey. The struggle of these larger mills to solve their waste problems has resulted in an efficient use for fuel or the location of good markets that have considerably raised the value of wood waste. This subject of value and its tie-up with availability is discussed further in a later section.

The Distribution of Wood Waste

As in northeastern Ohio, plants were classified according to the number in each weekly waste production class. Figure 12 gives this information as well as the key to the type of manufactured product made at the various mills.

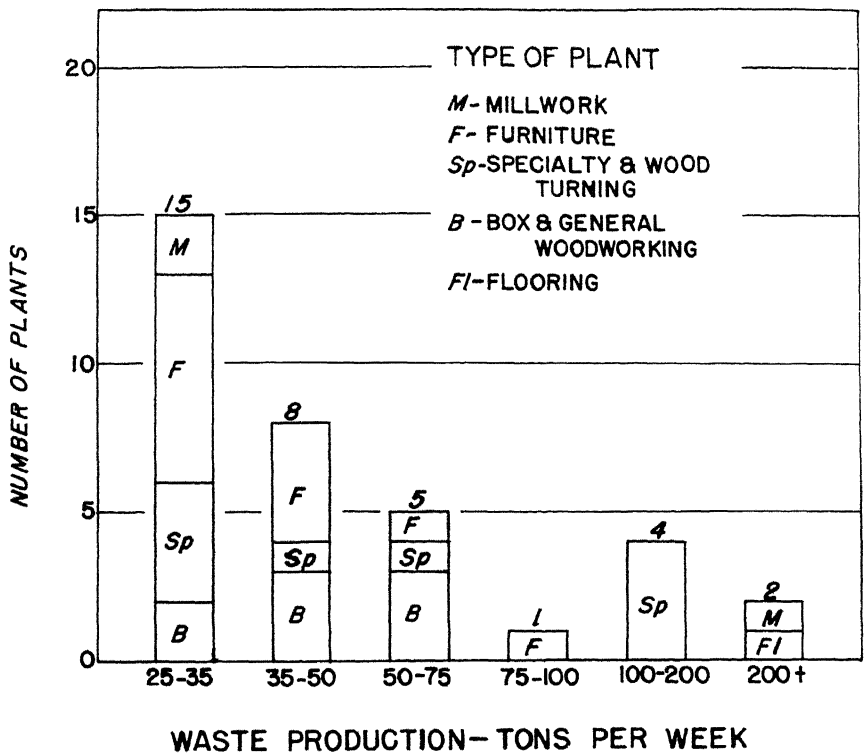

Fig. 12.—The segregation of weekly waste production at 35 large secondary mills in northwestern, southwestern, and southeastern Ohio according to number and type of plants.

The plants that produce the most waste are a millwork plant that produces large quantities of shavings and a flooring mill that produces large quantities of chips and cuttings (hogged). Next are four specialty and turning mills (in these cases, handle plants) that produce large quantities of shavings and some cuttings. Waste production from these six factories alone is nearly 1,000 tons per week, or almost one-half of the entire production in the 65 counties surveyed. It can be readily seen that an acquisition program should be centered about a few of these key plants.

Handling and Transportation

Since the plants visited on this survey were all large in size, almost all have railroad sidings. Likewise, nearly all have cyclone systems for collecting sawdust and shavings. Few factories, however, are set up to blow sawdust, shavings, and hogged material directly into box cars. However, the changes in the blower system required to accomplish the task would quite often be minor. Where sidings are limited in size or waste production is insufficient to fill a car before it incurrs demurrage charges, it becomes necessary to have a storage bin within easy access of the siding that can hold at least 1½ to 3 carloads of material. Many plants do not have such bins at the present time.

The Value of Wood Waste

In canvassing the larger secondary wood-using industries, it seemed that most plants could be grouped into three classifications in regards to the value of wood waste. As mentioned previously, value can have a decided effect on availability and this point should be borne in mind. The value groupings are listed as follows:

A. Waste sold on a low value market, dumped, or even given away. Such waste is low in value and would be readily available for a dollar or two per ton, sometimes merely for the hauling.

B. Waste sold on a medium value market or burned for fuel. Such fuel is often stoked by hand and is usually inefficiently burned. The management may not be satisfied with waste as fuel, but finds this the best way of solving the disposition problem. The value is variable, seldom exceeding $3 to $4 per ton. This waste is usually available for new markets.

C. Waste sold on a high value market or burned for fuel at optimum value. Handling large volumes of waste, these plants have developed efficient systems for handling and burning the material and at present are usually well satisfied with the system they have evolved. Material in this group is often not available or of doubtful availability. One operator described the situation well when he stated, "We would sell our waste if it proved profitable, but with coal at $8 per ton and freight and unloading costs at $4, wood at half the value of coal is worth $6 per ton. We would have to get that much plus enough more to make it worthwhile to make necessary changes in our collection and fuel system. The value is $5 to $6 per ton".

The percentage of total waste produced in each of the foregoing classes is approximately as follows:

Class A	Class B	Class C
25 percent	25 percent	50 percent

CONCLUSIONS

Wood waste is produced in sufficient quantities to be considered favorably as a raw material for further manufacturing.

That so much of our valuable timber resources must go unused today is indeed regrettable, but there are stringent economic and technical limitations that have hampered efforts to put this material to its best use.

Following is an analysis of some of the more important obstacles in the waste utilization field along with suggested solutions and an account of current efforts to overcome these problems:

The Economics of Handling and Transportation. Wood waste as a raw material has usually been considered more expensive than raw wood for the same use (except in by-product utilization at the factory of origin). Eventually, this situation may correct itself. If raw wood in its more conventional forms continues to rise in price, either because of scarcity or increased demand due to its replacement of less renewable natural resources, wood waste may come into its own as a raw material.

Loading and transportation are the critical costs in waste utilization. Few places were found where the problem has been solved satisfactorily. Loading and handling should be by mechanical means. Cuttings should be handled on conveyors within the plant and preferably hogged for ease of loading and unloading. All fine material should be handled by blower systems that may have to be portable in certain cases. Storage bins may be necessary to hold material until enough accumulates for efficient loading. Such bins must be designed and located for efficient loading.

Specifications for material. Wood waste cannot be considered a "universal raw material". Rigid specifications on species and size of material seriously affect the amount available for a given purpose. Manufacturers using wood waste must pass up such material if they cannot accept mixtures of species. With material ranging from sawdust to coarse hogged waste carried in a single collection system, it may be necessary to screen and discard part of the waste, separate it to be processed in different "batches", or to reprocess it, reducing the particules to a more uniform size.

Waste Utilization Processes. Technically, there are many successful waste utilization processes. Many, however, are unsuitable economically. The most promising possibilities seem to lie in the manufacture of plastics, wallboard, wood molasses, and paper. This last item (paper) has become a possibility in Ohio only since recent advancements in processes for converting hardwoods to pulp (10).

Special Machinery. Slabwood would seem ideally suited for the production of wood chips, providing the bark can be removed. The supply would be virtually unlimited. An estimated total of from 175,000,000 to 300,000,000 tons is produced yearly from Ohio's sawmills. At present there are no machines within the price range of the small mill operator that will efficiently remove the bark from slabwood. There are a few mills in the country that debark logs or slabs, but the machinery is suitable only for the large mill. There are four solutions to this problem, namely: (1) The debarking of logs before they are sawed. This would require relatively expensive, heavy machinery. (2) The debarking of slabs in lighter semi-portable or portable equipment (as yet undeveloped for the small mill) (3). The development of efficient means to remove the bark from chipped wood (4). The development of products and processes that can accept the large percentage of bark found in chips from slabs.

The debarking of slabwood after sawing seems to be the most practicable solution for small Ohio sawmills. The type of machine needed must be light enough to be part of portable sawmill equipment, preferably set up to handle slabs as they come off the saw. It must remove a high percentage of the bark (85-90 percent) with little wood loss, and it must be inexpensive. The chain barker principle might be adapted to such specifications, being cheap, light in weight, and a fairly effective debarker.

Hogged cuttings are not entirely satisfactory for pulping. A machine is needed to replace the conventional wood hog that will produce a more uniform chip. Existing machinery may solve this problem. One company hogs its waste in a well-known make of hammermill (with ½-inch screen) to produce small wood chips of fairly uniform size.

Some of these problems have led members of the wood-using industries to look upon wood waste as a problem about which little could be done. Such should not be the case. During the course of this survey, contact was made with the Northeastern Wood Utilization Council, with E. W. Fobes, F. C. Simmons, M. R. Brundage, and R. K. Day of the Forest Utilization Service of the U. S. Forest Service, and with R. K. Winters and J. T. Morgan, Forest Economists, U. S. Forest Service, as well as private industry in the waste production and waste utilization fields. Several of these men gave help in planning the study. From all these sources came evidence of progress in the waste utilization field. New advancements in pulping and new fibre processes are being studied. Experts are working on debarkers and chippers. More efficient systems of loading are being studied, as are transportation costs. All these activities are taking place in the waste utilization (or closely allied) fields.

RELATED LITERATURE

1 Abstracts on Utilization of Sawdust. National Research Council of Canada, 1946.

2 Aries, R. S., Problems in the Utilization of Sawdust. Bull. No. 16. Northeastern Wood Utilization Council, 1947.

3 Wood Waste, A Challenge to Industry and Science. Bul. No. R1631. Forest Products Lab., 1947.

4 Pulping Characteristics of Available Lake States and Northeastern Woods. Bul. No. R1675. Forest Products Lab., 1947.

5 Briquetting of Wood Waste. Bull. No. R482. Forest Products Lab. Rev. 1945.

6 Cahal, R. R.; More Intensive Utilization of Sawmill Waste. Southern Pine Inspection Bureau. New Orleans, 1942.

7 General Recommendations Regarding Methods for Wood Waste Utilization. Bull. No. R1666. Forest Products Lab., 1947.

a Uses for Sawdust and Shavings. No. R1666-1.

b Uses for Slabs, Edgings, and Trims. No. R1666-2.

c Uses for Forest Waste. No. R1666-3.

d Reduction of Waste in the Veneer and Plywood Industry. No. R1666-4.

e Chemical Composition and uses of Bark. No. R1666-5.

f Reinke, L. H.; Wood Flour. No. R1666-9.

g Synthetic Board Materials and Molded Produces from Wood Waste. No. R1666-7.

h Beglinger, L. H; Charcoal Production. No. R1666-11.

i Briquettes from Wood Waste. No. R1666-13.

j Sawdust-Cement Concrete. No. R1666-15.

k Use of Short Boards in Sheathing Crates. No. R1666-17.

8 Hawley, L. F.; Chemical Utilization of Wood Waste. Forest Products Lab., 1931.

9 Insulation Board, Wallboard, and Hardboard. Bul. No. R1677. Forest Products Lab., 1947.

10 New Developments in Hardwood Pulp. Northeastern Wood Utilization Council, New Haven, 1947.

11 Wood Notes. Northeastern Wood Utilization Council, New Haven, 1947.

12 . Wood Waste in The United States; Report 4 from a Reappraisal of the Forest Situation. Forest Service, USDA, 1947.

APPENDIX

In the appendix are tables containing the detailed basic data for each county in the state. Data for northeastern Ohio are in part A and for the remainder of the state in part B.

APPENDIX A

TABLE I - A—Current production of wood waste in 23 northeastern Ohio counties. Waste produced in each county is tabulated in detail by the volume of each class of material.

County	Number of Mills	Total Waste Produced Per County Tons Per Week	Waste Production from Secondary Plants— Tons Per Week			Waste Production from Primary Mills— Tons Per Week	
			Sawdust & Shavings	Small Cuttings	Unclassified	Sawdust & Shavings	Slabs, Trims & Edgings
Ashland	5	98	—	—	—	33	65
Ashtabula	9	186	50	10	—	12	84
Carroll	13	219	—	—	—	75	144
Columbiana	9	183	10	5	—	56	112
Coshocton	13	232	15	—	—	73	144
Cuyahoga	27	635	231	37	340	27	*
Erie	2	42	—	—	—	14	28
Geauga	11	231	—	—	—	77	154
Harrison	6	121	20	*	—	34	67
Holmes	12	269	—	—	—	93	176
Huron	4	41	—	—	10	10	21
Jefferson	11	241	—	—	10	77	154
Lake	2	36	—	—	15	7	14
Lorain	9	189	—	—	—	63	126
Mahoning	22	464	100	*	10	118	236
Medina	6	87	30	*	—	20	37
Portage	6	112	10	—	25	26	51
Richland	13	355	—	—	—	118	237
Stark	6	122	10	*	54	26	32
Summit	9	248	199	5	22	7	15
Trumbull	13	250	5	*	—	82	163
Tuscarawas	7	228	60	—	—	56	112
Wayne	7	146	28	32	8	38	40
Totals	222	4,735	768	89	494	1,172	2,212

* Unestimated

In many cases cuttings are a relatively small item in the wood waste and are not figured in the estimates. Where all waste is burned, it usually is not possible to get a breakdown on the classes of waste. In most secondary plants sawdust and shavings are blown into a bin together and no breakdown figures are available

TABLE II - A—Wood waste production in each of 23 northeastern Ohio counties tabulated by the number of mills and the total waste production (from both primary and the secondary mills) per week.

Size of Plants	Cuyahoga Co. Number Plants	Cuyahoga Co. Output Tons/Wk.	Wayne Co. Number Plants	Wayne Co. Output Tons/Wk.	Medina Co. Number Plants	Medina Co. Output Tons/Wk.	Summit Co. Number Plants	Summit Co. Output Tons/Wk.	Stark Co. Number Plants	Stark Co. Output Tons/Wk.
5–10	12	75	1	8	3	15	3	20	1	10
10–19	7	100	3	48	1	17	4	48	2	35
20–29	2	40	—	—	1	20	—	—	2	45
30–39	2	65	3	90	1	35	1	30	1	32
40–49	1	40	—	—	—	—	—	—	—	—
50	—	—	—	—	—	—			—	—
100	1	115	—	—	—	—	1	150	—	—
200	1	200	—	—	—	—	—	—	—	—
Total	27	635	7	146	6	87	9	248	6	122
	Holmes Co.		Ashland Co.		Richland Co.		Huron Co.		Erie Co.	
5–10	—	—	—	—	—	—	3	20	—	—
10–19	3	45	1	11	—	—	—	—	—	—
20–29	6	122	4	87	5	105	1	21	2	42
30–39	3	102	—	—	7	210				
40–49	—	—	—	—	1	40	—	—	—	—
Total	12	269	5	98	13	355	4	41	2	42
	Lorain Co.		Caroll Co.		Tuscarawas Co.		Lake Co.		Ashtabula Co.	
5–10	—	—					—	—		
10–19	—	—	6	70	—	—	1	15	3	45
20–29	9	189	7	149	1	21	1	21	4	81
30–39	—	—	—	—	5	157	—	—	2	60
40–49	—	—	—	—	1	50	—	—	—	—
Total	9	189	13	219	7	228	2	36	9	186
	Geauga Co.		Portage Co.		Trumbull Co.		Columbiana Co.		Jefferson Co.	
5–10	—	—	—	—	1	5	—	—	—	—
10–19	—	—	3	45	7	101	4	60	2	25
20–29	11	231	3	67	1	24	3	63	6	126
30–39	—	—	—	—	4	120	2	60	3	90
40–49	—	—	—	—	—	—	—	—	—	—
Total	11	231	6	112	13	250	9	183	11	241
	Harrison Co.		Coshocton Co.		Mahoning Co.					
5–10	—	—		—	3	30				
10–19	2	26	7	97	3	45				
20–29	3	65	5	105	14	329				
30–39	1	30	1	30	2	60				
40–49	—	—	—	—	—	—				
Total	6	121	13	232	22	464				

In addition there are small woodworking plants and small and part-time sawmills turning out small quantities of waste (1, 2, 3 tons per week) and an undisclosed number (not surveyed) turning out negligible amounts. It was not deemed advisable to make a complete check on these smaller mills because their waste production is often intermittent and in such small quantities; thus making it impractical to collect and transport waste to any but small local markets.

TABLE III-A—A tabuation of waste disposal in each of 23 northeastern Ohio counties. Within each 'disposal class" waste is further classified according to its probable availability for new markets.

Waste Disposal Class:—	Burned for Fuel				Sold			Given Away or Dumped	
	Tons Per Week				Tons Per Week			Tons Per Week	
	Available for New Market?				Available for New Market?			Available for New Market?	
County	Yes	No	Question able	Total Burned	Yes	No	Total Sold	Yes	Total Dumped or Given Away
Ashland	—	—	—	—	16	—	16	82	82
Ashtabula	50	—	—	50	14	—	14	122	122
Carroll	—	—	—	—	21	—	21	198	198
Columbiana	—	—	—	—	—	—	—	183	183
Coshocton	—	—	—	—	38	—	38	194	194
Cuyahoga	155 217*	7	130	192	8	46	54	83	83
Erie	—	—	—	—	28	—	28	11	14
Geauga	—	—	—	—	—	—	—	231	231
Harrison	—	—	—	—	37	—	37	84	84
Holmes	—	—	15	15	70	—	70	184	184
Huron	10	—	—	10	14	—	14	17	17
Jefferson	—	—	—	—	44	—	44	197	197
Lake	15	—	—	15	—	—	—	21	21
Lorain	—	—	—	—	—	—	—	189	189
Mahoning	—	—	—	—	24	40	64	400	400
Medina	45	—	—	45	27	—	27	15	15
Portage	25	—	—	25	—	—	—	87	87
Richland	—	—	—	—	55	—	55	300	300
Stark	24	6	10	40	73	—	73	9	9
Summit	166	—	—	166	14	—	14	68	68
Trumbull	—	—	—	—	21	—	21	229	229
Tuscarawas	—	—	—	—	71	—	71	157	157
Wayne	4	—	4	8	76	3	79	48	48
Totals	711	13	159	566	651	89	740	3,112	3 112

* Burned in the winter onlv.

APPENDIX B

TABLE 1-B—Wood waste production from secondary mills in southwestern, southeastern, and northwestern Ohio (producing 25 or more tons per week) tabulated according to its disposal and probable availability.

Classes of Waste	Disposal of Waste Tons Per Week			Availability for New Markets— Tons Per Week			
	Sold	Burned	Dumped or Given Away	Availability	Not Available	Available Questionable	
Southwestern Ohio							
Sawdust	10	4	30	14	—	—	
Sawdust & Shavings	20	75	—	75	—	20	
Shavings	—	46	5	51	—	—	
Cuttings	25	115	—	140	—	—	
Cuttings, Hogged	—	10	—	10	—	—	
No Breakdown	25	565	50	520	—	120	
Sub Total 1	80	815	85	840	—	140	(980)
Southeastern Ohio							
Sawdust	—	—	—	—	—	—	
Sawdust & Shavings	—	50	20	70	—	—	
Shavings	—	—	40	10	—	—	
Cuttings	—	55	10	65	—	—	
Cuttings, Hogged	—	—	—	—	—	—	
No Breakdown	240	115	—	305	—	50	
Sub Total	240	220	70	180	—	50	(530)
Northwestern Ohio							
Sawdust	—	—	—	—	—	—	
Sawdust & Shavings	15	290	—	185	—	120	
Shavings	—	—	—	—	—	—	
Cuttings	—	60	—	60	—	—	
Cuttings, Hogged	—	60	—	60	—	—	
No Breakdown	—	230	35	35	85	145	
Sub Total	15	640	35	340	85	265	(690)
TOTAL	355	1,675	190	1,660	85	455	
	GRAND TOTAL 2,200			GRAND TOTAL 2,200			

TABLE II - B—Current production of wood waste from secondary mills (producing 25 or more tons per week) in southwestern, southeastern, and northwestern Ohio. Waste produced in each county is tabulated in detail by the volume of each class of material.

County	Number of Mills	Waste Production — Tons Per Week						
		Sawdust	Shavings	Sawdust & Shavings Mixed	Cuttings	Cuttings, Hogged	Unclassified	Total Waste Produced Per County
Southwestern Ohio								
Clermont	1	—	—	—	—	—	25	25
Delaware	1		Unestimated					
Fayette	1	—	—	—	—	—	50	50
Franklin	3	—	—	35	10	10	—	55
Greene	1	—	—	—	—	—	35	35
Hamilton	6	10	30	50	70	—	395	555
Knox	1	—	—	—	—	—	35	35
Miami	1	4	16	—	20	—	—	40
Montgomery	4	30	5	10	40	—	100	185
Sub-Total	19	44	51	95	140	10	640	980
Southeastern Ohio								
Athens	1		Unestimated — Probably 25 tons per wk.					
Belmont	1	—	20	—	—	—	—	20
Guernsey	2	—	20	20	10	—	—	50
Hocking	1	—	—	—	—	—	50	50
Morgan	1	—	—	20	10	—	—	30
Noble	1	—	—	—	—	—	40	40
Scioto	1	—	—	—	—	—	25	25
Washington	3	—	—	30	45	—	240	315
Sub-Total	11	—	40	70	65	—	355	530
Northwestern Ohio								
Allen	1	—	—	—	—	—	55	55
Auglaize	1		Unestimated					
	1	—	—	15	—	—	85	100
Crawford	1	—	—	—	—	—	35	35
Defiance	1	—	—	120	—	—	—	120
Lucas	1	—	—	—	—	60	—	60
Mercer	1		Unestimated					
	1	—	—	—	—	—	90	90
Williams	2	—	—	170	60	—	—	230
Sub-Total	10	—	—	305	60	60	265	690
TOTAL	40	44	91	470	265	70	1,260	2,200

* The remainder of the counties in the area had no mills producing large quantities of waste. These counties are listed on page 29.

The following counties in southwestern, southeastern and north western Ohio had no mills producing large quantities of waste.

S. W. Ohio

Adams	Highland	Preble
Brown	Logan	Pike
Butler	Madison	Ross
Champaign	Marion	Union
Clark	Morrow	Warren
Clinton	Pickaway	

S. E. Ohio

Fairfield	Lawrence	Monroe
Gallia	Licking	Muskingum
Jackson	Meigs	Perry
		Vinton

N. W. Ohio

Darke	Ottawa	Van Wert
Fulton	Paulding	Wood
Hancock	Putnam	Wyandot
Hardin	Sandusky	Shelby
Henry	Seneca	